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A revival of the "Mie problem"

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Abstract: A revival of "the Mie" problem, a revival of a book and contemporary research view on nanoparticles optical properties

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Introduction

The present paper wishes to be a kind of historical revival of an "old book" that is hardly available especially to young generations of researchers and students. A bit of confusion is present also in Wikipedia. The topic is the "Mie problem" and the book[1] is a famous "Optical Properties of Metal Clusters" by Kreibig and Vollmer (Springer 1995), red with the eyes of 2024. Young generations often know well the detail of their studies and experiments but lack dramatically of an historical and wide perspective on their job, and it's a pity. Technics but a little of "cultural heritage" which may be able to clarify views and put into a wider context a research work. This paper may be useful as a step toward a more conscious way of working on metal nanoparticles.

"The Mie Problem"

The Mie problem was the electrodynamic exact calculus-which means to solve the Maxwell equations- for metallic clusters (much smaller than λ, the field wavelength) in an external electromagnetic field. He solved it in 1908[2]. Mie solved the Maxwell equations with proper boundary conditions in spherical coordinates with a multipolar expansion of the incident field. The input parameters were the size of the particle and the optical functions of particles and surrounding medium. Mie derivation was revisited by Born, in his famous book3 "Optics" while a more mathematical formalism was introduced by Stratton4 and which is presently more common than the original Mie version.

Purposes of the "Mie Solution"

Mie's purpose was to understand extinction spectra (absorption +scattering, the experimental output is always extinction) of experiments of Steubing5. Mie solution divided the problem in two parts: the electromagnetic part, treated with first principles, and the material problem, with the introduction of a phenomenological dielectric function (ε (ω, R)) taken from experiment or from models.

Limitation of the "Mie Theory"

"Mie Theory" is phenomenological, and does not give insights on the material properties such electron motion, the presence of discrete auto states (QSE, quantum size effect).

60 years after…

1968, more or less, "Mie absorption" was interpreted with concepts of electronic collective excitations, plasmonic oscillations of different multipolar orders: plasmon polaritons. In contrast "free plasmons" are only exited by electrons, not by an electromagnetic field. This notation seems to come from Schopper6, in analogy with the bounded plasma oscillations. Mie calculations are restricted to uncharged clusters.

Debye Solution

Debye6 solved the "Mie Problem" almost simultaneously, but from a different perspective: he calculated the radiation pressure-the light pressure-the mechanical pressure on the particle due to interaction with light.

The Debye solution was not so famous ad the Mie one, because this mechanical pressure was extremely low at that time: nowadays with laser light is at the basis of the functioning systems like optical tweezers for "laser manipulation".

References

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